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# Influence of body condition and bovine somatotropin on estrous behavior, reproductive performance, and concentrations of serum somatotropin and plasma fatty acids in postpartum Brahman-influenced cows[1,2]

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**ABSTRACT:** Ninety-nine multiparous Brahman-influenced (1/4 to 3/8 Brahman) cows were managed to achieve low (BCS = 4.3 ± 0.1; n = 50) or moderate (BCS = 6.1 ± 0.1; n = 49) body condition (BC) to determine the influence of bovine somatotropin (bST) on estrous characteristics, reproductive performance, and concentrations of serum GH and plasma NEFA. Beginning 32 d postpartum, cows within each BC were assigned randomly to treatment with or without bST. Non-bST-treated cows received no treatment, and treated cows were administered bST (Posilac, 500 mg s.c.) on d –35, –21, and –7 before initiation of the breeding season. On d –7, all cows received an intravaginal, controlled internal drug-releasing (CIDR) device. On d 0 (initiation of the 70-d breeding season), the CIDR were removed and cows received prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$). Blood samples were collected from the median caudal vein of the cows at each bST treatment and at d –28 and 0. Estrous behavior was monitored by radiotelemetry during the first 30 d of the breeding season. Growth hormone was increased ($P < 0.05$) in low and moderate BC cows treated with bST. The percentage of cows detected in estrus during the first 30 d of the breeding season was decreased ($P = 0.05$) for low BC (64%) compared with moderate BC (82%) cows. The interval to first estrus tended ($P = 0.07$) to be shorter in low BC-bST-treated cows (3.7 ± 1.9 d) than in moderate BC-bST-treated cows (9.6 ± 1.8 d). During the first 30 d of the breeding season, cows in low BC had a decreased ($P = 0.02$) number of mounts received and increased ($P = 0.001$) quiescence between mounts compared with cows in moderate BC. The number of mounts received was reduced ($P = 0.04$) in bST-treated cows. More ($P = 0.02$) cows treated with bST became pregnant during the first 3 d of the breeding season compared with non-bST-treated cows. The cumulative first-service conception rate tended ($P = 0.07$) to be greater for bST-low BC cows than non-bST-treated cows in low or moderate BC. On d 0, NEFA were greater ($P < 0.05$) in bST-treated vs. non-bST-treated cows. Low BC and bST reduced the intensity of behavioral estrus in postpartum Brahman-influenced cows. However, bST increased the first-service conception rate during the first 30 d of breeding and pregnancy rates during the first 3 d of breeding in postpartum Brahman-influenced cows.

**Key words:** beef cow, body condition, conception rate, estrous behavior, somatotropin


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## INTRODUCTION

Reproduction of cows is influenced by nutrient intake and subsequent changes in body energy reserves (Richards et al., 1986; Randel, 1990). Cows in thin body condition (**BC**) at calving have an extended postpartum anestrous period and may not become pregnant during the breeding season (Richards et al., 1986; Selk et al., 1988). Although the effects of body energy reserves on

[1]Names are necessary to report factually on available data; however, the USDA does not guarantee or warrant the standard of the product, and the use of the name by the USDA implies no approval of the product to the exclusion of others that also may be suitable.

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reproductive performance are well established, data on the influence of BC on estrous behavior are minimal. Recently, Ciccioli et al. (2003) reported that the duration of estrus and number of mounts received during the first postpartum estrus were similar between primiparous beef cows fed a moderate- or high-energy diet.

Somatotropin regulates animal growth and development (Gluckman et al., 1987), and somatotropin receptors are found in numerous reproductive tissues of cattle (Lucy et al., 1993; Kirby et al., 1996). Administration of recombinant bovine somatotropin (**bST**) increases GH in cattle (Andrade et al., 1996; Bilby et al., 1999) and is an effective method to test the influence of GH on reproductive performance (Lucy, 2000). The influence of bST on reproduction is dependent on BC (Spicer et al., 1990; Lucy, 2000), and GH is increased in nutrient-restricted cattle (Armstrong et al., 1993; Bossis et al., 1999). A major action of GH is increased lipolysis (Burton et al., 1994; Bauman, 1999), and bST treatment increased NEFA in dairy cows (Santos et al., 2000; Gulay et al., 2003). Numerous studies have focused on the effects of bST on reproduction in dairy cattle (De La Sota et al., 1993; Kirby et al., 1997a,b; Lucy, 2000); however, less in known concerning how bST affects estrous characteristics and reproductive performance of beef cattle, specifically Brahman-influenced cattle.

The objectives of this study were to evaluate the effects of BC and bST on estrous characteristics, fertility, and concentrations of serum GH and plasma NEFA in postpartum Brahman-influenced beef cows.

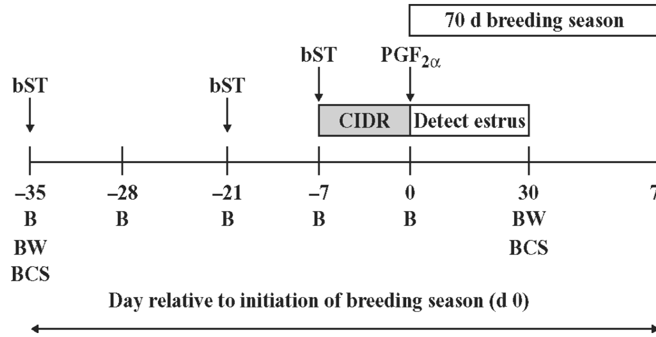



**Figure 1.** Timeline of specific experiment events with Brahman-influenced cows in low or moderate body condition treated with or without bovine somatotropin (bST); blood (B) samples collected on d –35, –28, –21, –7, and 0; BW and BCS recorded on d –35 and 30; CIDR = intravaginal, controlled internal drug-releasing device, and $PGF_{2\alpha}$ = prostaglandin $F_{2\alpha}$.

## MATERIALS AND METHODS

### *Description of the Animals and Experimental Procedures*

The committee for animal welfare at the USDA-ARS, Dale Bumpers Small Farms Research Center, Booneville, AR, approved the animal procedures used in this study. Spring-calving, crossbred (1/4 to 3/8 Brahman; mean age = 3.7 ± 1.3 yr) multiparous cows were managed to achieve a low or moderate BC at the initiation of the breeding season. Cows in mid- to late gestation grazed stockpiled and spring-growth, endophyte-infected tall fescue (*Festuca arundinacea* Schreb.) pastures at a stocking rate of 1 cow/0.3 ha (low BC) or 1 cow/0.8 ha (moderate BC) for approximately 162 d before the initiation of treatment. Cows were offered a mineral premix (ProPhos 6 Mag, Land O'Lakes, Shoreview, MN) ad libitum. Mean BCS of low (n = 50; mean BW = 424 ± 16 kg) and moderate (n = 49; mean BW = 530 ± 16 kg) BC cows was 4.3 ± 0.1 and 6.1 ± 0.1 (1 = emaciated to 9 = obese; Wagner et al., 1988), respectively. All BCS were visually estimated by the same 2 independent evaluators throughout the experiment.

Calving dates for low and moderate BC cows ranged from 21 February to 28 March (mean date = 9 March) and 24 February to 2 April (mean date = 14 March), respectively. The calves were allowed to suckle their dams throughout the experiment. Beginning 32 ± 2 d postpartum, BW and BCS were recorded on all cows, and cows within each BC group were assigned randomly to treatment with or without bST, in a 2 × 2 factorial arrangement. Non-bST-treated cows received no treatment, and treated cows were administered bST (500 mg; Posilac, St. Louis, MO) subcutaneously along the lateral surface of the dorsal one-third of the neck on d –35, –21, and –7 before the breeding season. Non-bST-treated cows were handled similarly to the bST-treated cows through a livestock chute. On d –7, all cows were moved to common Bermudagrass [*Cynodon dactylon* (L.) Pers] pastures at a stocking rate of 1 cow/0.8 ha and offered a mineral premix (ProPhos 8, Land O'Lakes). Cows received an intravaginal, controlled internal drug-releasing [**CIDR**, 1.38 g of progesterone (**$P_4$**), Pfizer Animal Health, New York, NY) device on d –7 (Figure 1). On d 0 (initiation of the 70-d breeding season), the CIDR were removed, and all cows received prostaglandin $F_{2\alpha}$ (**$PGF_{2\alpha}$**, 25 mg i.m., Lutalyse, Pfizer Animal Health).

On d 0, all cows were fitted with a radiotelemetry [Heatwatch (**HW**), DDx Inc., Denver, CO] transmitter and were exposed to bulls (1 bull/21 cows); the bulls had successfully passed a breeding soundness examination. Estrous activity was recorded during the first 30 d of the 70-d breeding season (initiation date = 20 May). Activities associated with estrus were recorded for each cow and included the date and time of the onset of estrus, the number of mounts received, the duration (h) of estrus, and the quiescent period. Mean quiescence was defined as the interval between each successive mount and was calculated as mean quiescence period = duration of estrus, h/(number of mounts received – 1) (Flores et al., 2006). Mounts were defined as standing events lasting 2 s or more between the beginning and end of estrus, as detected by HW. The first of 2 mounts within 4 h determined the onset of estrus. Termination of estrus was the final mount, with a single mount 4 h before, and no activity during the next 12 h (White et al., 2002; Flores et al., 2006). Cows that lost their HW transmitter after the initiation of estrus were removed from the statistical analyses for synchronization rate and estrous characteristics but were included in the analyses for the proportion of cows in estrus and the interval to estrus after treatment. Body weight and BCS were obtained from all cows at HW transmitter removal (d 30 of the 70-d breeding season).

The synchronization rate was defined as the number of cows that exhibited behavioral estrus, as detected by HW during the first 3 d of the breeding season after CIDR-$PGF_{2\alpha}$ treatment, divided by the total number of cows in each group. First-service conception rate was defined as the number of cows detected in estrus via HW that became pregnant, divided by the total number of cows with a HW-detected estrus during the first 3 and 30 d of the breeding season. Date of first-service conception was determined by subtracting 285 d from the calf's birth date and was confirmed by a HW-detected estrus. Pregnancy rate was defined as the number of cows that became pregnant during the first 3 d or the entire 70-d breeding season, divided by the total number of cows in each group.

### *Blood Collection and Hormone and NEFA Analyses*

Blood samples were collected from cows at each bST treatment (d –35, –21, and –7; serum and plasma) and d –28 (serum only) and 0 (serum and plasma) before the breeding season. Blood samples were collected by venipuncture of the median caudal vein, allowed to clot for 24 h at 4°C (serum only), and centrifuged (1,500 × *g* for 25 min). Serum and plasma samples were stored at –20°C until analyses.

Serum concentrations of GH were determined in a single assay, as described by Hoefler and Hallford (1987), with an intraassay CV of 8%. Serum samples collected on d –35, –28, and –21 were analyzed for concentrations of $P_4$ using a Coat-A-Count kit (Diagnostic Products Corp., Los Angeles, CA; Schneider and Hallford, 1996) to determine the percentage of anestrous cows at the initiation of bST treatment; intra- and interassay CV were 5 and 1%, respectively. Sensitivity of the assay was 0.05 ng/mL. Cows were classified as anestrus if the concentrations of $P_4$ were <1 ng/mL in the weekly blood samples or cyclic if the concentrations of $P_4$ were ≥1 ng/mL (Wettemann et al., 1972) in at least 1 blood sample. Plasma concentrations of NEFA on d –35, –21, –7, and 0 were determined by an enzymatic colorimetric procedure (NEFA-C, Wako Chemicals Inc., Dallas, TX) adapted for use in a 96-well microtiter plate system and expressed as microequivalents of palmitate per liter (Johnson and Peters, 1993). Intra- and interassay CV were 2.9 and 2.8%, respectively; sensitivity of the assay was 50 mEq/L.

### *Statistical Analyses*

Data were analyzed by ANOVA as a 2 × 2 factorial arrangement of treatments (low or moderate BC and bST or no bST treatment) within a completely randomized design, with cow as the experimental unit. Days postpartum, BW, and BCS at the initiation of treatment were analyzed by ANOVA utilizing the GLM procedure (SAS Inst. Inc., Cary, NC). The model included bST treatment, BC, and the interaction. The percentage of anestrous cows at initiation of bST treatment was analyzed with the CATMOD procedure of SAS, with a model that included bST treatment, BC, and the interaction.

The change in BW and BCS between the initiation of bST treatment and d 30 of the breeding season were analyzed by ANOVA utilizing the GLM procedure of SAS, with a model that included bST treatment, BC, and the interaction. The mean interval to first detected estrus after CIDR removal and $PGF_{2\alpha}$ treatment was analyzed using the GLM procedure of SAS. The model included bST treatment, BC, and the interaction.

Based on our previous report (Flores et al., 2006) and others (Lucy et al., 2001), a majority (56 to 59%) of cows should be in estrus 3 d after treatment with a CIDR and $PGF_{2\alpha}$. The percentage of cows exhibiting estrus during the first 3 d; first-service conception rates on d 1, 2, or 3; and the 3-d cumulative pregnancy rates were analyzed with the CATMOD procedure of SAS, with a model that included bST treatment, BC, and the interaction. The above statistical analysis also was performed on data collected during the first 30 d of the breeding season and included the percentage of cows exhibiting estrus, cumulative first-service conception rate, and pregnancy rate for the 70-d breeding season. The effect of bST treatment, BC, and the interaction on the duration of estrus, number of mounts received, and quiescence between mounts during the first 3 and 30 d of the breeding season was analyzed by ANOVA using the MIXED procedure of SAS. The number of days postpartum was different ($P = 0.002$) between low and moderate BC at the initiation of bST treatment; therefore, days postpartum was used as a covariate in all of the aforementioned models.

Comparisons of concentrations of GH and NEFA were analyzed using the MIXED procedure of SAS for repeated measures (Littell et al., 1998). The model included bST treatment, BC, day, and all interactions. The most appropriate covariance structure was chosen from unstructured, compound symmetric, spatial power, and antedependence structures utilizing Akaike's Information Criterion and Schwarz' Bayesian Criterion (Littell et al., 2000). Kenward-Rogers's approximation was used for calculation of the df of the pooled error term. The random effect of cow within each BC and bST treatment (specified in the SUBJECT statement) accounted for the correlations among repeated observations on the same cow. If bST treatment × day, BC × day, or bST treatment × BC × day was

**Table 1.** Least squares means (±SE) for BW, BCS, days postpartum, and number of anestrous Brahman-influenced cows in low or moderate body condition (BC) at the initiation of bovine somatotropin (bST) treatment[1]

| | Treatment | | | | P-value | | |
|---|---|---|---|---|---|---|---|
| | Non-bST | | bST | | | | |
| Item | Low BC[2] | Moderate BC[3] | Low BC | Moderate BC | Treatment[4] | BC | Treatment × BC |
| No. of cows | 25 | 24 | 25 | 25 | — | — | — |
| BW, kg | 427.9 ± 15.8 | 531.0 ± 16.1 | 419.3 ± 15.8 | 529.2 ± 15.8 | 0.74 | 0.001 | 0.83 |
| BCS[5] | 4.3 ± 0.1 | 6.1 ± 0.1 | 4.2 ± 0.1 | 6.1 ± 0.1 | 0.68 | 0.001 | 0.83 |
| Postpartum, d | 33.2 ± 2.2 | 28.3 ± 2.0 | 37.2 ± 2.2 | 29.0 ± 1.9 | 0.25 | 0.002 | 0.44 |
| No. anestrus[6] | 21 (84) | 19 (79) | 18 (72) | 19 (76) | 0.36 | 0.91 | 0.58 |

[1]Cows were treated with (500 mg s.c.) or without bST (non-bST) every 2 wk for 6 wk before initiation of the breeding season.
[2]Low BC (BCS = 4.3 ± 0.1; Wagner et al., 1988).
[3]Moderate BC (BCS = 6.1 ± 0.1).
[4]Treatment = non-bST vs. bST.
[5]1 = emaciated, 9 = obese; Wagner et al., 1988.
[6]Percentages in parentheses.

significant ($P < 0.05$), means separations were evaluated on each day using the PDIFF function of SAS.

Survival analysis utilizing the LIFETEST procedure of SAS was used to evaluate the effects of bST treatment and BC on the interval to first detected estrus and the interval to pregnancy during the first 30 d of the breeding season. For the interval to first estrus, the survival analysis was a regression of the number of cows not detected in estrus with HW during the first 30 d of the breeding season, and cows not detected in estrus were included in the statistical analysis as censored observations. The Wilcoxon test was used to examine the differences between the survival curves. Survival analysis for the interval to pregnancy during the first 30 d of the breeding season was performed using the aforementioned methods. Cows that were detected in estrus during the first 30 d of the breeding season, exposed to bulls, and did not become pregnant were censored for pregnancy analyses.

Correlation analyses were used to evaluate the associative relationships among GH, NEFA, and the reproductive parameters. Correlation coefficients were generated with the CORR procedure of SAS.

## RESULTS

### *Characteristics of the Cattle*

A bST treatment × BC interaction did not influence ($P > 0.44$; Table 1) BW, BCS, days postpartum, or number of anestrous cows at initiation of bST treatment. Moderate BC cows were heavier ($P = 0.001$) and had greater BCS ($P = 0.001$) than low BC cows at the initiation of bST treatment (Table 1). Mean days postpartum at the initiation of bST treatment were greater ($P = 0.002$) for low BC cows than moderate BC cows. The number of cows anestrous at the initiation of bST treatment was not ($P = 0.91$) influenced by BC (Table 1). Mean BW, BCS, days postpartum, and the number of anestrous cows were similar ($P > 0.25$) between non-bST-treated and bST-treated cows at initiation of bST treatment (Table 1). Seventy-eight percent (77/99) of cows were anestrous at the initiation of bST treatment.

### *Body Weight and BCS Change*

Change in BW between the initiation of bST treatment (d −35 before start of the breeding season) and d 30 of the breeding season was not influenced ($P > 0.10$) by bST or BC (data not shown) or by both. Overall, all cows gained 0.4 ± 0.1 kg/d during the experiment. Change in BCS was not influenced ($P = 0.81$) by bST. However, change in BCS was influenced ($P < 0.001$) by BC. Cows in low BC gained (0.3 ± 0.1) condition, whereas moderate BC cows lost condition (−0.5 ± 0.1) between the initiation of bST treatment (d −35 before the breeding season) and d 30 of the breeding season.

### *Synchronization, First-Service Conception, and Pregnancy Rates in First 3 Days*

Percentage of cows detected in estrus, first-service conception, and pregnancy rates during the first 3 d of the breeding season were not affected ($P > 0.13$) by a bST treatment × BC interaction (Table 2). Synchronization rate, defined as number of cows with a HW-detected estrus divided by total number of cows, was not influenced by bST ($P = 0.31$) or BC ($P = 0.29$), and averaged 51% (50/99; Table 2). First-service conception rates during the first 3 d of the breeding season were greater ($P = 0.01$) in bST-treated cows compared with nonbST-treated cows (Table 2). Similarly, pregnancy rates were greater ($P = 0.02$) for cows treated with bST than non-bST-treated cows during the first 3 d of the breeding season (Table 2).

### *Cumulative Percentage in Estrus, Interval to Conception, First-Service Conception, and Pregnancy Rates*

During the first 30 d of the breeding season, a bST × BC interaction did not influence ($P = 0.73$) the percent-

**Table 2.** Influence of body condition (BC) and bovine somatotropin (bST) on synchronization rate, first-service conception rate, and pregnancy rate of Brahman-influenced cows during the first 3 d of the breeding season[1]

| | Treatment | | | | *P*-value | | |
|---|---|---|---|---|---|---|---|
| | Non-bST | | bST | | | | |
| Item | Low BC[2] | Moderate BC[3] | Low BC | Moderate BC | Treatment[4] | BC | Treatment × BC |
| No. of cows | 25 | 24 | 25 | 25 | — | — | — |
| Synchronization rate,[5] % | 40 (10/25) | 54 (13/24) | 56 (14/25) | 52 (13/25) | 0.31 | 0.29 | 0.13 |
| First-service conception rate,[5] % | 30 (3/10) | 15 (2/13) | 50 (7/14) | 62 (8/13) | 0.01 | 0.52 | 0.49 |
| Pregnancy rate,[5] % | 12 (3/25) | 8 (2/24) | 28 (7/25) | 32 (8/25) | 0.02 | 0.85 | 0.60 |

[1]Cows were treated with (500 mg s.c.) or without bST (non-bST) every 2 wk for 6 wk before initiation of breeding season.
[2]Low BC (BCS = 4.3 ± 0.1; Wagner et al., 1988).
[3]Moderate BC (BCS = 6.1 ± 0.1).
[4]Treatment = non-bST vs. bST.
[5]Number of observations in parentheses; synchronization rate was the number of cows with a Heat Watch (HW)-detected estrus divided by the total number of cows in the group; first-service conception rate was the number of cows with HW-detected estrus that became pregnant divided by the total number of cows with a HW-detected estrus; and pregnancy rate was the number of cows that became pregnant divided by the total number of cows in the group.

age of cows detected in estrus (Table 3). However, BC influenced ($P = 0.05$) the percentage of cows detected in estrus during the first 30 d of the breeding season such that a greater percentage of moderate BC cows (82%) were detected in estrus compared with low BC cows (64%; Table 3). Interval to conception was not influenced ($P = 0.38$) by a bST × BC interaction (Table 3). Interval to conception following CIDR-PGF$_{2\alpha}$ was shorter ($P = 0.05$) for moderate BC compared with low BC cows (Table 3).

A bST treatment × BC interaction tended ($P = 0.07$) to influence cumulative first-service conception rate during the first 30 d of the breeding season. Cumulative first-service conception rates were greater for bST-moderate BC cows (67%) compared with bST-low BC cows (44%), and bST-low BC cows had a increased cumulative first-service conception rate compared with non-bST-treated cows in low (31%) or moderate (26%) BC (Table 3). Pregnancy rate for the 70-d breeding season was not affected ($P = 0.36$) by a bST × BC interaction (Table 3). There was a tendency ($P = 0.09$) for more cows in moderate BC to become pregnant (78%) during the cumulative 70-d breeding season than cows in low BC (62%; Table 3).

### *Interval to First Estrus and Estrous Characteristics*

Interval to first estrus after CIDR removal and PGF$_{2\alpha}$ administration tended ($P = 0.07$) to be influenced by a bST treatment × BC interaction; mean interval to first estrus was shorter for bST-low BC cows than bST-moderate BC cows (Table 4). Duration of estrus and number of mounts received during the first 3 d of the breeding season were not influenced ($P > 0.40$) by a bST treatment × BC interaction (Table 4). Mean duration of estrus during the first 3 d of the breeding season was influenced ($P = 0.01$) by BC; cows in low BC had a shorter duration of estrus than moderate BC cows (Table 4). During the first 3 d of the breeding season, number of mounts received was influenced ($P = 0.002$) by BC and tended ($P = 0.07$) to be affected by bST treat-

**Table 3.** Influence of body condition (BC) and bovine somatotropin (bST) on the percentage of Brahman-influenced cows detected in estrus, the interval to conception, and the cumulative first-service conception rate during the first 30 d of the breeding season, and the cumulative 70-d breeding season pregnancy rate[1]

| | Treatment | | | | *P*-value | | |
|---|---|---|---|---|---|---|---|
| | Non-bST | | bST | | | | |
| Item | Low BC[2] | Moderate BC[3] | Low BC | Moderate BC | Treatment[4] | BC | Treatment × BC |
| No. of cows | 25 | 24 | 25 | 25 | — | — | — |
| Estrus,[5] % | 64 (16/25) | 79 (19/24) | 64 (16/25) | 84 (21/25) | 0.73 | 0.05 | 0.73 |
| Interval to conception, d | 26.2 ± 4.6 | 20.7 ± 3.6 | 26.6 ± 5.0 | 13.9 ± 3.6 | 0.45 | 0.05 | 0.38 |
| First-service conception rate,[5] % | 31 (5/16) | 26 (5/19) | 44 (7/16) | 67 (14/21) | 0.01 | 0.30 | 0.07 |
| Pregnancy rate,[5] % | 60 (15/25) | 83 (20/24) | 64 (16/25) | 72 (18/25) | 0.58 | 0.09 | 0.36 |

[1]Cows were treated with (500 mg s.c.) or without bST (non-bST) every 2 wk for 6 wk before initiation of the breeding season.
[2]Low BC (BCS = 4.3 ± 0.1; Wagner et al., 1988).
[3]Moderate BC (BCS = 6.1 ± 0.1).
[4]Treatment = non-bST vs. bST.
[5]Number of observations in parentheses.

**Table 4.** Influence of body condition (BC) and bovine somatotropin (bST) on the interval to estrus and estrous characteristics during the first 3 d of the breeding season of Brahman-influenced cows[1]

| | Treatment | | | | | | |
|---|---|---|---|---|---|---|---|
| | Non-bST | | bST | | *P*-value | | |
| Item | Low BC[2] | Moderate BC[3] | Low BC | Moderate BC | Treatment[4] | BC | Treatment × BC |
| No. of cows | 25 | 24 | 25 | 25 | — | — | — |
| Interval to estrus, d | 6.4 ± 2.1 | 5.0 ± 2.1 | 3.7 ± 1.9 | 9.6 ± 1.8 | 0.63 | 0.28 | 0.07 |
| Range | 1 to 23 | 2 to 25 | 1 to 24 | 2 to 25 | — | — | — |
| Duration of estrus, h | 5.4 ± 1.7 | 8.2 ± 1.2 | 3.0 ± 1.5 | 8.1 ± 1.2 | 0.37 | 0.01 | 0.40 |
| Range | 0.8 to 17.0 | 1.3 to 17.4 | 1.2 to 18.0 | 0.6 to 15.0 | — | — | — |
| No. of mounts received | 15.6 ± 6.8 | 34.5 ± 4.9 | 3.4 ± 6.1 | 26.0 ± 5.0 | 0.07 | 0.002 | 0.73 |
| Range | 3 to 37 | 5 to 94 | 3 to 23 | 3 to 48 | — | — | — |
| Quiescence between mounts, h | 0.4 ± 0.1 | 0.3 ± 0.1 | 0.8 ± 0.1 | 0.3 ± 0.1 | 0.03 | 0.004 | 0.05 |
| Range | 0.1 to 1.8 | 0.1 to 0.7 | 0.2 to 1.6 | 0.2 to 0.7 | — | — | — |

[1]Cows were treated with (500 mg s.c.) or without bST (non-bST) every 2 wk for 6 wk before initiation of the breeding season.
[2]Low BC (BCS = 4.3 ± 0.1; Wagner et al., 1988).
[3]Moderate BC (BCS = 6.1 ± 0.1).
[4]Treatment = non-bST vs. bST.

ment (Table 4). Cows in moderate BC had greater number of mounts than low BC cows, and non-bST-treated cows tended to receive more mounts than bST-treated cows during the first 3 d of the breeding season. Quiescence between mounts was influenced ($P = 0.05$) by a bST treatment × BC interaction. Cows treated with bST in low BC had greater mean quiescence between mounts compared with non-bST-treated-low BC, non-bST-treated-moderate BC, and bST-moderate BC cows during the first 3 d of the breeding season (Table 4).

Estrous characteristics during first 30 d of the breeding season were not influenced by a bST treatment × BC interaction ($P > 0.31$; Table 5). Mean duration of estrus during first 30 d of the breeding season was not influenced by bST treatment or BC ($P > 0.32$), or both, and averaged 6.7 ± 1.3 h (Table 5). Cows treated with bST had decreased ($P = 0.04$) mean number of mounts received than non-bST-treated cows. Low BC cows received fewer ($P = 0.02$) mounts than moderate BC cows during the first 30 d of the breeding season (Table 5). Cows in low BC also had longer ($P = 0.001$) mean quiescence between mounts than moderate BC cows during estrus (Table 5).

### Estrus and Pregnancy Survival Curves

There was no effect ($P > 0.10$) of BC or bST treatment on survival curves for cows not detected in estrus during the first 30 d of the breeding season (data not shown). However, treatment with bST did influence ($P = 0.05$) the proportion of cows not pregnant during the first 30 d of the breeding season (Figure 2). Cows treated with bST underwent the most rapid decline in the proportion of cows not pregnant during the first 10 d of the breeding season compared with non-bST-treated cows. Body condition did not influence ($P > 0.10$) the proportion of cows not pregnant during the first 30 d of breeding season.

### Concentrations of GH and NEFA

Serum concentrations of GH ($P = 0.01$) were influenced by a bST treatment × BC × day interaction (Figure 3). Low and moderate BC cows treated with bST had greater concentrations of GH on d –28, –21, –7, and 0 compared with low and moderate BC, non-bST-treated cows. Low BC, bST-treated cows had greater ($P < 0.05$) concentrations of GH on d –28, –21, –7, and 0 than moderate BC, bST-treated cows. Plasma concentrations of NEFA were influenced by a BC × day ($P = 0.03$) and treatment × day ($P = 0.001$) interaction (Figure 4). On d –7 and 0, moderate BC cows had greater ($P < 0.05$) concentrations of NEFA than low BC cows (Figure 4A). Cows treated with bST had greater concentrations of NEFA on d 0 (initiation of breeding) than non-bST-treated cows (Figure 4B).

### Correlations Among Variables

Concentrations of NEFA on d –21 ($r = –0.36$; $P = 0.001$) and –7 ($r = –0.38$; $P = 0.001$) were inversely correlated with BW change between the initiation of bST treatment (d –35 before the breeding season) and d 30 of the breeding season (data not shown). Likewise, NEFA on d –7 ($r = –0.33$; $P = 0.001$) and 0 ($r = –0.17$; $P = 0.08$) were negatively correlated with BCS change.

Duration of estrus tended to be negatively correlated with concentrations of GH on d –35 ($r = –0.22$; $P = 0.09$) and concentrations of NEFA on d 0 ($r = –0.20$; $P = 0.09$; data not shown). Number of mounts received during estrus tended to be negatively correlated with concentrations of GH on d –28 ($r = –0.22$; $P = 0.09$) and –7 ($r = –0.22$; $P = 0.08$) before the breeding season (data not shown). Concentrations of GH tended ($P = 0.10$) to be positively correlated to concentrations of NEFA ($r = 0.17$).

**Table 5.** Influence of body condition (BC) and bovine somatotropin (bST) on estrous characteristics of Brahman-influenced cows during the first 30 d of the breeding season[1]

| | Treatment | | | | *P*-value | | |
|---|---|---|---|---|---|---|---|
| | Non-bST | | bST | | | | |
| Item | Low BC[2] | Moderate BC[3] | Low BC | Moderate BC | Treatment[4] | BC | Treatment × BC |
| No. of cows | 25 | 24 | 25 | 25 | — | — | — |
| Duration of estrus, h | 7.6 ± 1.4 | 7.1 ± 1.4 | 6.2 ± 1.3 | 5.8 ± 1.2 | 0.32 | 0.77 | 0.99 |
| Range | 0.8 to 17.0 | 0.6 to 17.4 | 1.2 to 18.0 | 0.6 to 15.0 | — | — | — |
| No. of mounts received | 14.7 ± 4.5 | 29.9 ± 4.5 | 10.1 ± 4.1 | 16.5 ± 3.8 | 0.04 | 0.02 | 0.31 |
| Range | 3 to 37 | 3 to 94 | 3 to 23 | 3 to 48 | — | — | — |
| Quiescence between mounts, h | 0.8 ± 0.1 | 0.4 ± 0.1 | 0.8 ± 0.1 | 0.4 ± 0.1 | 0.99 | 0.001 | 0.55 |
| Range | 0.1 to 1.8 | 0.1 to 0.8 | 0.2 to 1.6 | 0.2 to 0.7 | — | — | — |

[1]Cows were treated with (500 mg s.c.) or without bST (non-bST) every 2 wk for 6 wk before initiation of breeding season.
[2]Low BC (BCS = 4.3 ± 0.1; Wagner et al., 1988).
[3]Moderate BC (BCS = 6.1 ± 0.1).
[4]Treatment = non-bST vs. bST.

## DISCUSSION

Limited data exist on effects of BC, somatotropin, and the interaction on reproductive performance of beef cattle, especially Brahman-influenced cows. Fewer thin cows were detected in estrus during the first 30 d of the breeding season than moderate-conditioned cows in the current experiment. Similarly, primiparous, lactating cows (Spitzer et al., 1995), as well as multiparous, nonlactating cows (Richards et al., 1989a) in thin BC (BCS ≤ 4) failed to exhibit estrus during the breeding season. Although low body energy reserves reduce overall reproductive performance in cattle, a paucity of research exists on the relationship between BC and estrous characteristics in cattle. Mean duration of estrus and number of mounts received in the current experiment were comparable with our previous report of estrous characteristics in Brahman-influenced cows treated with CIDR and $PGF_{2\alpha}$ (Flores et al., 2006). In the current study, cows in low BC exhibited a shorter estrus during the synchronized estrus (first 3 d) and had decreased number of mounts received during the first 3 and 30 d of the breeding season compared with moderate BC cows. Quiescence between mounts also was longer in low BC cows than moderate BC during the first 30 d of the breeding season. Number of mounts received and duration of estrus was similar between moderate BC (mean BCS = 5.5) Brahman-influenced cows with or without luteal activity at the initiation of the breeding season (Flores et al., 2006). Duration of estrus and total estrous activity was similar in dairy heifers in moderate and fat BC visually observed twice daily (Villa-Godoy et al., 1990). Ciccioli et al. (2003) reported duration of estrus and number of mounts received monitored by radiotelemetry were not affected by BC at calving or postpartum nutrition in primiparous, Hereford × Angus cows. Differences between studies may be attributed to larger differences in BCS between moderate and thin cows in the current experiment than the other studies. Further, all cows in the current experiment were treated with CIDR and $PGF_{2\alpha}$. The decreased intensity of estrous behavior in low BC cows in the current experiment may be due to fewer cows in estrus simultaneously. Synchronization rate was similar between low and moderate BC during the first 3 d of the breeding season, but fewer cows in low BC were detected in estrus during the first 30 d of the breeding season. Recently, we (Flores et al., 2006) reported treatment of Brahman-influenced cows with CIDR and $PGF_{2\alpha}$ initiated estrous cycles in cows lacking luteal activity at the start of the breeding season. However, cows in that study were in moderate BC (mean BCS = 5.5). Increasing the number of cows in estrus at the

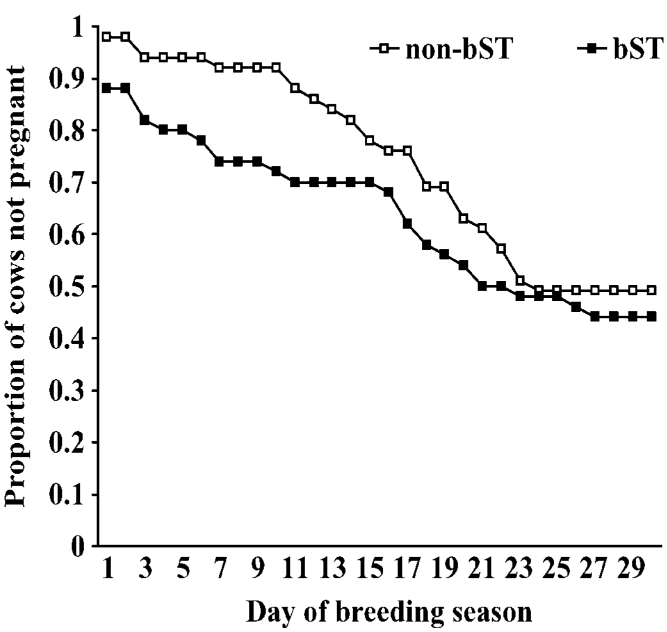



**Figure 2.** Survival curve for the proportion of Brahman-influenced cows treated with bovine somatotropin (bST) every 2 wk for 6 wk before initiation of the breeding season or without bST (non-bST) and not pregnant during the first 30 d of the breeding season; $P = 0.05$.

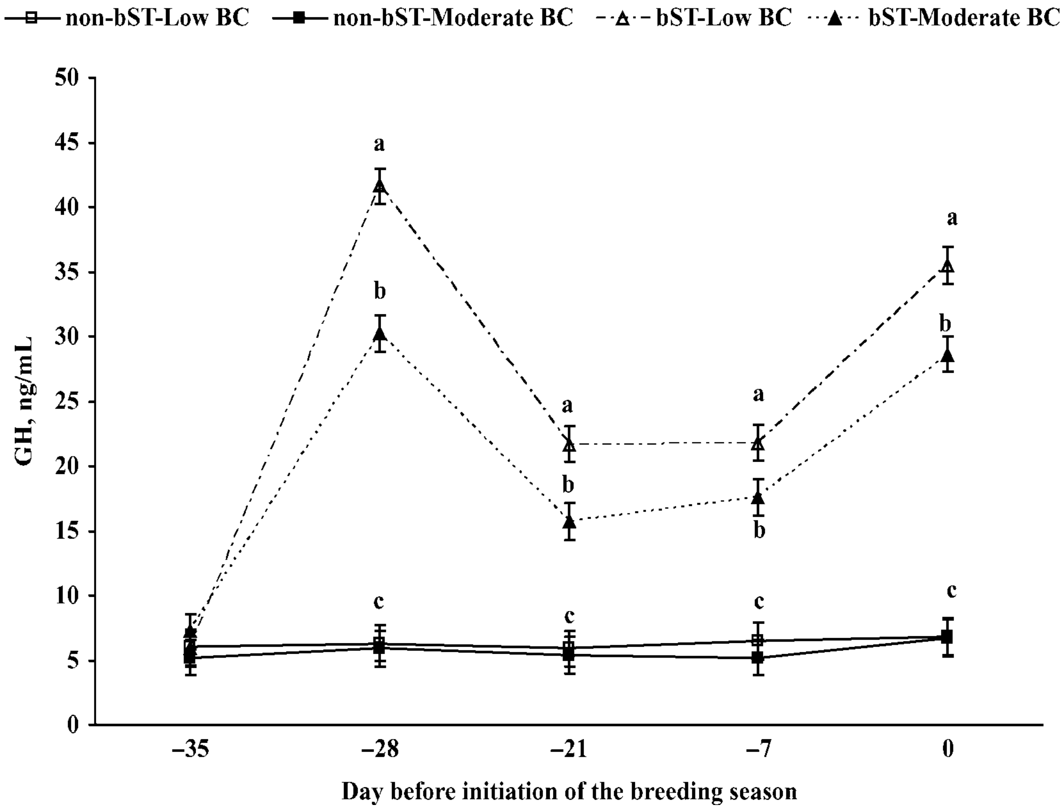



**Figure 3.** Serum concentrations of GH of low (BCS = 4.3 ± 0.1) and moderate (BCS = 6.1 ± 0.1) body condition (BC), Brahman-influenced cows treated with bovine somatotropin (bST) or without (non-bST). Cows were treated with bST every 2 wk for 6 wk before initiation of the breeding season (d 0). Blood was collected at each bST treatment (d –35, –21, and –7) and at d –28 and 0. Growth hormone was influenced ($P$ = 0.01) by a bST × BC × day interaction. [a–c]Within a day, means without common superscripts differ ($P$ < 0.05).

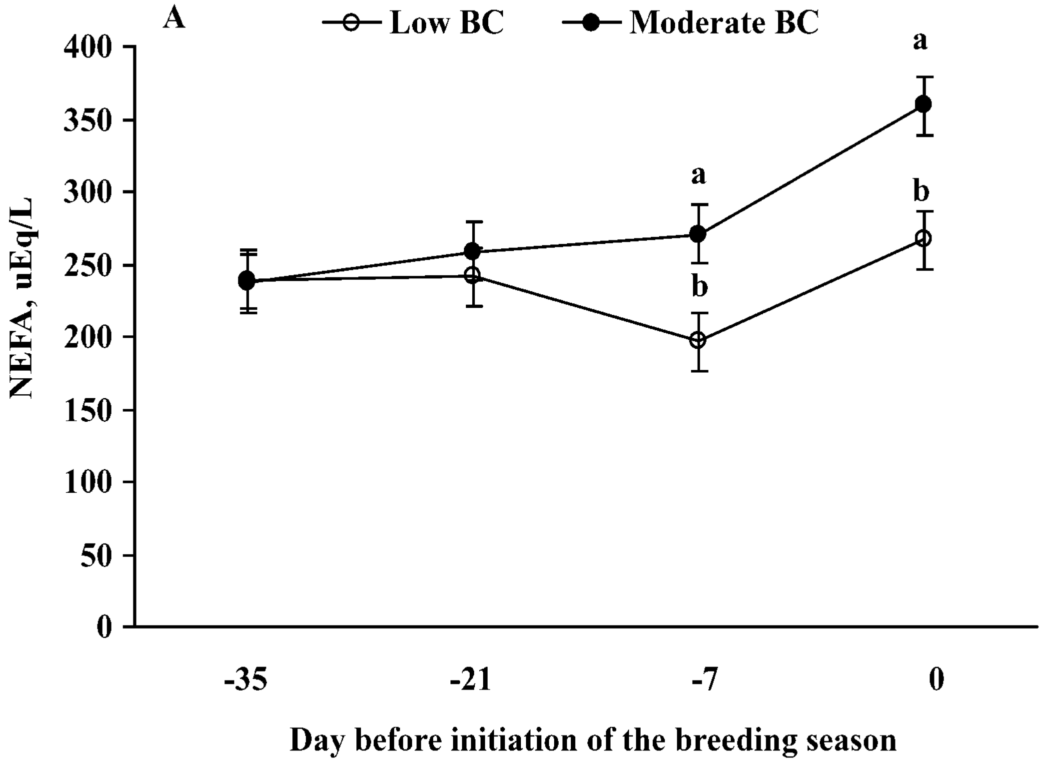
same time influences estrous behavior (Hurnik et al., 1975; Floyd et al., 2001; Flores et al., 2006). Although we did not measure concentrations of estradiol in the current experiment, follicle development in low BC cows may have been jeopardized resulting in impaired steroidogenesis and decreased concentrations of estradiol and reduced estrous behavior. Estrus may be absent in anestrous cows (Wettemann and Bossis, 2000) and cows with short-lived corpora lutea (Braden et al., 1989) because of insufficient estrogen synthesis from compromised follicular development. Perry et al. (1991) found postpartum cows fed low energy diets had smaller estrogen-active follicles than cows fed adequate dietary energy. In the current experiment, intensity of estrous behavior was reduced in thin cows and could be a result of fewer cows in estrus simultaneously or possibly inadequate concentrations of estrogen to stimulate estrous behavior, or both.

Treatment with bST reduced the number of mounts received by estrual cows during the first 3 and 30 d of the breeding season. Estrous detection rate decreased linearly as concentration of bST administered to primiparous dairy cows increased (Morbeck et al., 1991), and multiparous dairy cows treated with bST had increased behavioral anestrus (Esteban et al., 1994). Further, Kirby et al. (1997b) reported an increased incidence of undetectable estrus in dairy cows treated with bST; however, ovulation rate was not altered by bST. In the current study, duration of estrus, as well as number of mounts received, tended to be inversely correlated with concentrations of GH before the breeding season. As in other studies (Andrade et al., 1996; Bilby et al., 1999), bST increased concentrations of GH in the current experiment. Cattle in negative energy balance typically have increased concentrations of GH (Armstrong et al., 1993; Bossis et al., 1999) due to decreased hepatic binding of GH (Keisler and Lucy, 1996). Reduction of the number of mounts received during estrus in bST-treated cows in the current experiment may be an evolutionary mechanism that decreases reproduction in undernourished cows (Kirby et al., 1997b).

Interval to conception was 9 d shorter for moderate BC cows compared with low BC cows in the current experiment. Cows with adequate BC have shorter intervals to first estrus and conception (Richards et al., 1986; Selk et al., 1988), and adequate BC has been associated with a shorter interval to first normal luteal activity in postpartum Hereford and Angus × Hereford cows (Looper et al., 2003).

Low and moderate BC cows treated with bST before the breeding season had greater first-service conception resulting in improved pregnancy rates during the first

A

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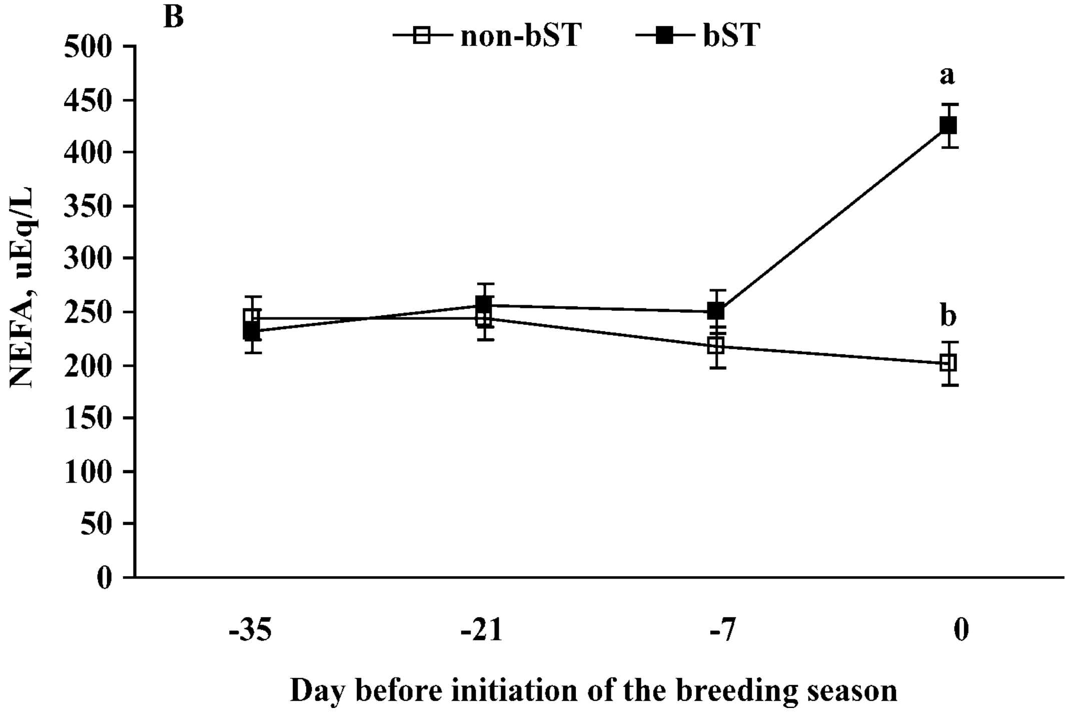


**Figure 4.** Plasma concentrations of NEFA of low (BCS = 4.3 ± 0.1) and moderate (BCS = 6.1 ± 0.1) body condition (BC), Brahman-influenced cows treated with bovine somatotropin (bST) or without (non-bST). Cows were treated with bST every 2 wk for 6 wk before initiation of the breeding season (d 0). Blood was collected at each bST treatment (d −35, −21, and −7) and at d 0. Concentrations of NEFA were influenced by a BC × day (A; $P = 0.03$) interaction and bST treatment × day (B; $P = 0.001$) interaction. [a,b]Within a day, means without common superscripts differ ($P < 0.05$).

3 d of the breeding season compared with non-bST-treated cows in low and moderate BC. Furthermore, bST-treated-low BC cows had increased cumulative first-service conception rates (first 30 d of the breeding season) compared with non-bST-treated cows in low or moderate BC. Effects of bST treatment on reproductive

performance in cattle are usually dependent on BC (Spicer et al., 1990). Our previous work (Flores et al., 2004) showed first-service conception rates and pregnancy rates were similar in moderate condition (BCS = 2.8; scale 1 to 5; Wildman et al., 1982), high-producing dairy cows treated with or without bST, and days to first-service tended to be less for bST-treated cows than non-bST-treated cows. Bilby et al. (1999) reported a 5% increase in conception rates of beef and dairy cows treated with bST compared with non-bST-treated cows. Improvement in first-service conception rates in cows treated with bST may be attributed to effects of GH on ovarian function since GH receptors are located within large cells of the corpus luteum of ruminants (Lucy et al., 1993; Yuan and Lucy, 1996), and treatment with bST increased concentrations of $P_4$ in cattle (Schemm et al., 1990; Gallo and Block, 1991; Lucy et al., 1994).

Cows treated with bST had greater plasma concentrations of NEFA than non-bST-treated cows at the initiation of the breeding season (d 0). Increased plasma NEFA on d 0 is probably due to bST treatment on d −7. We speculate plasma concentrations of NEFA were greater on d −28 and −14 (7 d after each respective bST treatment); however, plasma samples were not collected on d −28, and no blood samples were collected on d −14. A major activity of GH is increased lipolysis (Burton et al., 1994; Bauman, 1999), and treatment with bST increased concentrations of NEFA in dairy cows (Santos et al., 2000; Gulay et al., 2003). Overall, moderate BC cows lost BC during the experiment resulting in greater concentrations of NEFA in moderate BC cows 7 d before and at initiation of the breeding season. Loss of condition in moderate BC cows could possibly be explained by diet change because all cows were moved from fescue to common Bermudagrass pastures in midMay. However, this is unlikely because CP is usually greater in these Bermudagrass pastures than fescue pastures in May (11-yr mean = 13.8 vs. 12.3% CP, for Bermudagrass and fescue, respectively; our unpublished observations). Similar to our results, Lake et al. (2005) reported cows in low BC (BCS = 4) maintained condition, whereas moderate-condition (BCS = 6) cows lost BC during the first 60 d postpartum. Reduced visceral organ mass in thin cows, possibly decreasing maintenance requirements, may have been responsible for the increased efficiency of low BC cows (Molle et al., 2004; Hess et al., 2005). During negative energy balance, adipose tissue is catabolized allowing NEFA and glycerol to be used as energy sources (Richards et al., 1989b; Wettemann et al., 2003). Concentrations of NEFA were negatively correlated with BW and BCS changes in the current experiment; however, NEFA were not correlated to interval to first estrus. Similarly, concentrations of NEFA were not related to interval between calving and first ovulation in multiparous beef cows (Guedon et al., 1999), and concentrations of NEFA were not predictive of luteal activity in primiparous beef cows (Vizcarra et al., 1998).

Cows treated with bST had a faster rate of decline in the proportion of cows not pregnant (survival analysis) during the early breeding season compared with non-bST-treated cows in the current experiment. Moderate-condition dairy cows treated with bST prior to insemination had increased pregnancy rate to first synchronized service (Moreira et al., 2000). Cumulative 70-d breeding season pregnancy rates were decreased for cows in low BC compared with cows in moderate BC. An important factor influencing pregnancy rate is BC at calving (Selk et al., 1988). Beef cows with a BCS of 6 and 7 at calving had greater pregnancy rates than those with a BCS 4 and 5 (DeRouen et al., 1994; Lake et al., 2005).

Low BC as well as bST treatment reduced intensity of estrus in Brahman-influenced cows. Thin cows had a shorter synchronized estrus, received fewer mounts, and were inactive longer between mounts than moderate BC cows. Cows treated with bST received fewer mounts during estrus than non-bST-treated cows. Treatment of Brahman-influenced cows with bST improved first-service conception during the first 3 and 30 d of the breeding season, and 3-d pregnancy rates compared with non-bST-treated cows. Intensity of behavioral estrus may be reduced in thin, Brahman-influenced cows, and decreased estrous behavior could be associated with increased concentrations of GH in thin cows.

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